MULTI-MODEL EXTRACTION UTILITY (MMEU) & 2000-2006 ALBERTA METEOROLOGICAL DATA SET

USER'S GUIDE

Government of Alberta

Multi-Model Extraction Utility (MMEU) & 2002-2006 Alberta Meteorological Data Set

MMEU User's Guide

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For:

Alberta Environment

May 2009

ISBN No. 978-0-7785-8517-6 (Printed)
ISBN No. 978-0-7785-8518-3 (On-line)
Web Site: http://www.environment.gov.ab.ca

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BACKGROUND

In 2006, RWDI AIR Inc. (RWDI) created a unique software solution called the "Multi-Model Extraction utility" or "MMEU" for Alberta Environment (RWDI Project No. W06-5065A). The purpose of the MMEU software is to allow modellers to leverage existing mesoscale meteorological model outputs, originally developed for regional atmospheric chemistry and air quality modelling applications, for use in more traditional, regulatory air quality models (e.g., CALPUFF, AERMOD, ISC, RTDM).

At the time of MMEU's inception, only one year of mesoscale model results was available. Specifically, one year of model results was available from Environment Canada, Prairie & Northern Region. Environment Canada's dataset contains meteorological model outputs for the entire year of 2002 and was generated using the NCAR / Penn State Fifth Generation Mesoscale Meteorological model (MM5).

As part of this current contract, Alberta Environment retained RWDI to perform the following Tasks:

1. Review the 2002 Environment Canada MM5 outputs adopted in MMEU v2.0 and prepare a report that describes the overall model performance and provides general usage notes as it pertains to using these data in subsequent air quality modelling applications.

2. Run MM5 at 12 km resolution covering the same domain as the Environment Canada subset adopted in the MMEU for 2003, 2004, 2005, and 2006.

3. Update the MMEU software solution to enable it to ingest and provide outputs using the complete five years of MM5 data.

DELIVERABLES

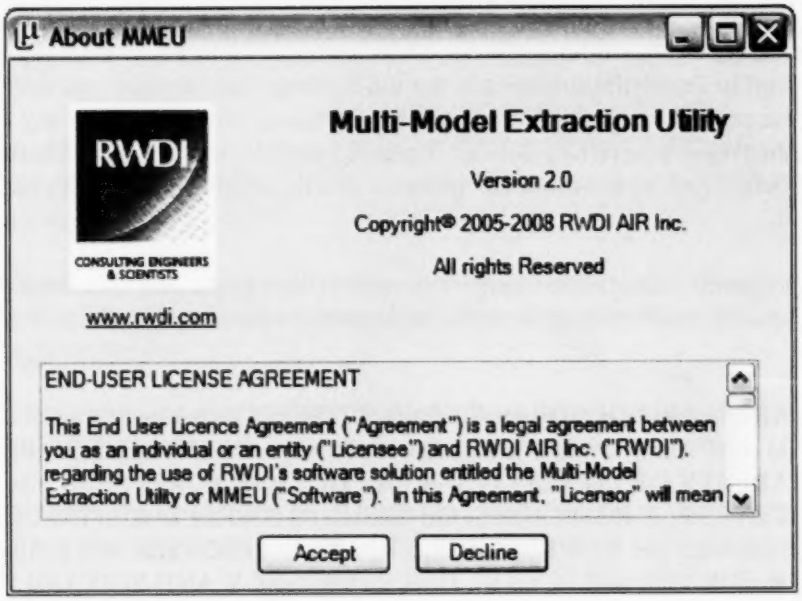
The report from Task 1 was provided to Alberta Environment as a standalone document entitled "*Review of Environment Canada 12 km MM5 Model Results – FINAL REPORT, for: Alberta Environment, RWDI Project W08-5014A, January 22, 2008*".

The MM5 model results for 2002, 2003, 2004, 2005, and 2006 as well as an updated version of the MMEU software (i.e., outputs from Tasks 2 and 3) were provided to Alberta Environment on an external USB hard drive. The MMEU application itself has been updated to extend the valid date ranges for which extractions can be performed.

The remainder of this document is comprised of the following technical appendices, which contain updated technical specifics concerning the MMEU solution itself, user tips, etc.

APPENDIX A. END USE LICENSE AGREEMENT

An End User License Agreement is included in the Executable version of the MMEU Software. Any individual or entity that installs and / or runs the MMEU software solution is consenting to be bound by the End User License Agreement. A copy of the terms and conditions of the End User License Agreement is provided in this appendix for reference. The End User License Agreement must be 'Accepted' when launching the MMEU software. The End User License Agreement can also be viewed by clicking the 'About' button on the main application window as shown below.


About MMEU
RWDI
CONSULTING ENGINEERS & SCIENTISTS
www.rwdi.com
Multi-Model Extraction Utility
Version 2.0
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Decline

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APPENDIX B. GENERAL USAGE NOTES

- Both Alberta Environment and RWDI are interested in receiving information and feedback on usage of the application, feature enhancement requests, bugs, etc. Please send suggestions, feedback and comments to: MMEU.Feedback@rwdi.com (a link is available from the About dialogue).

- MMEU was designed to run on the Windows 2000 (or higher) 32-Bit operating system with version 1.1 (or higher) of the .NET Framework. MMEU can be run from some network drives, depending on the security configuration of the local network.

- The Alberta 12 km MM5 files to be used with MMEU must be located on a single local or network drive prior to extraction (i.e., to extract data for all five years, MM5 files must be located in a single directory folder).

- MMEU does not currently support the performance of multiple extractions in a single execution (i.e., batch runs are not supported), nor does it support concurrent versions operating simultaneously.

- MMEU has been designed to work explicitly with the Alberta 12 km MM5 files provided with the application.

- No context sensitive help has been provided within the GUI. All of the information needed to execute a run is readily available in this document and / or on-screen in the GUI itself.

- All date specifications made by the user must be in local time (as opposed to GMT) and are for full days.

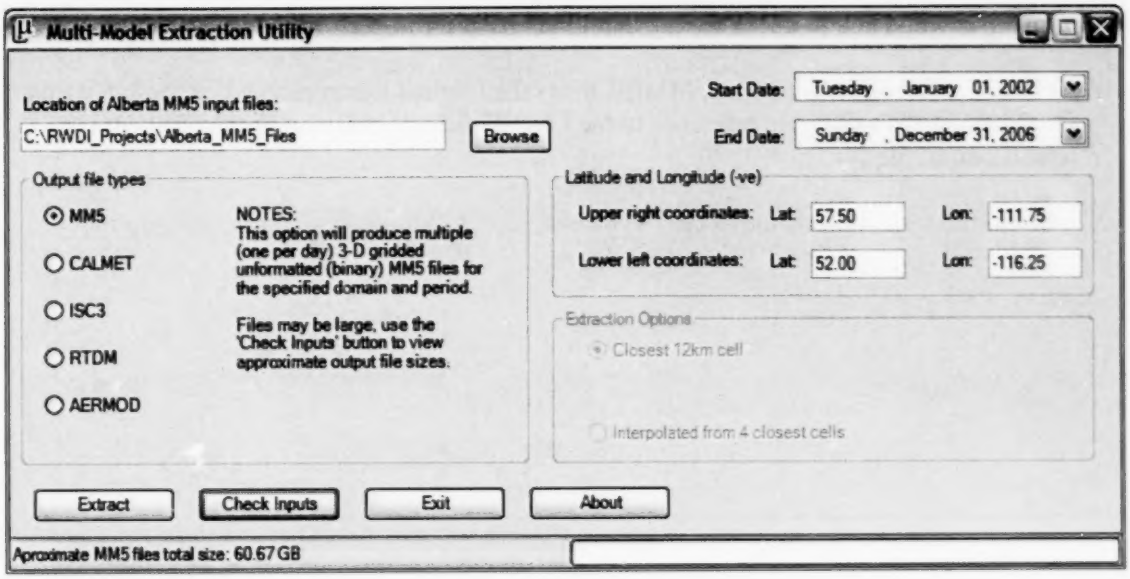
- Because of differences in GMT versus local time and hour indexing differences for different file formats, it may be necessary to access MM5 files for more days than those being extracted (i.e., one buffer day before or after the extraction period may be required).

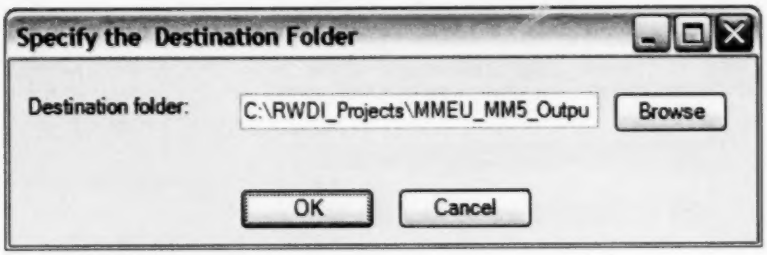
- The 'Check Inputs' button can be used to determine the estimated size of the output files prior to extraction. The onus is on the user to change the input parameters (namely period and / or domain extents) and re-check the resultant file size prior to performing an extraction. For the CALMET option, it is assumed that all 30 vertical levels will be extracted (see Appendix D for more details).

- The extents of the Alberta subset and hence extents for the extraction of outputs must fall within the following constraints:

Corners	MM5 Indices		Geographic		UTM Zone 11 NAD83		UTM Zone 12 NAD83	
	I	J	Longitude (degrees)	Latitude (degrees)	Easting (m)	Northing (m)	Easting (m)	Northing (m)
Lower Left	0	0	-120.7462	48.7207	224,488	5,403,185	-216,381	5,442,409
Lower Right	0	68	-109.3251	48.1543	1,070,615	5,362,003	624,567	5,334,808
Upper Left	108	0	-120.6712	60.6082	299,071	6,724,756	-28,194	6,758,122
Upper Right	108	68	-105.9450	59.9021	1,116,520	6,692,214	782,607	6,651,310

APPENDIX C. MM5 EXTRACTION OPTION


Multi-Model Extraction Utility
Location of Alberta MM5 input files:
C:\RWDI_Projects\Alberta_MM5_Files
Browse
Start Date: Tuesday , January 01, 2002
End Date: Sunday , December 31, 2006
Output file types
MM5
CALMET
ISC3
RTDM
AERMOD
NOTES:
This option will produce multiple (one per day) 3-D gridded unformatted (binary) MM5 files for the specified domain and period.
Files may be large, use the 'Check Inputs' button to view approximate output file sizes.
Latitude and Longitude (-ve)
Upper right coordinates: Lat: 57.50 Lon: -111.75
Lower left coordinates: Lat: 52.00 Lon: -116.25
Extraction Options
Closest 12km cell
Interpolated from 4 closest cells
Extract
Check Inputs
Exit
About
Aproximate MM5 files total size: 60.67 GB



MM5 Usage Notes

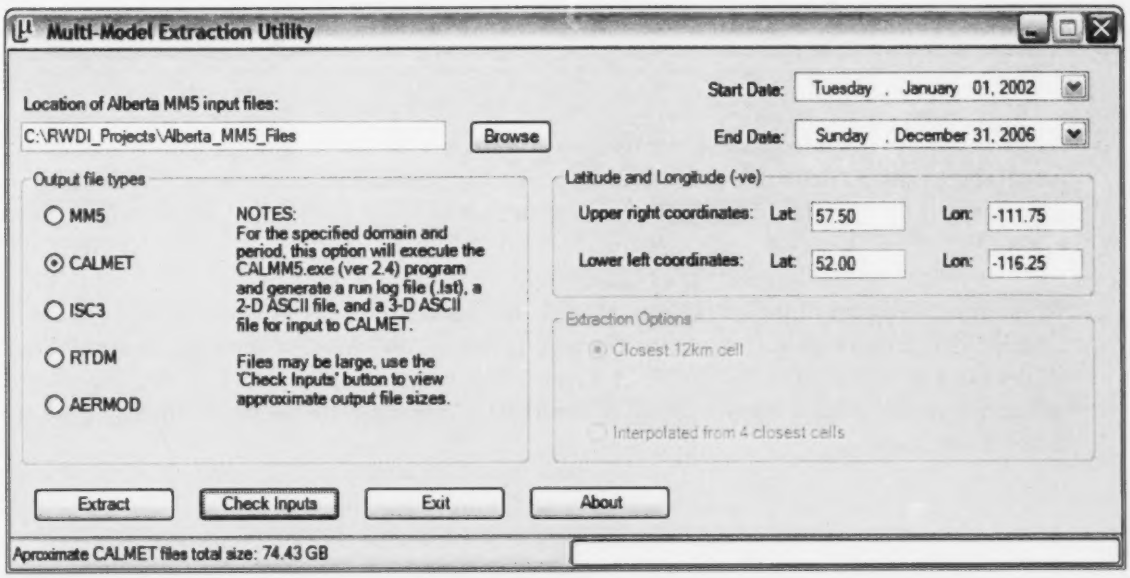
- This option produces multiple (one per day) 3-D gridded unformatted (PC-Binary) MM5 version 3.5 files for the specified sub-domain and period.
- Because the file naming convention adopted for the output files retains the same structure as the inputs, the destination folder must be different than the input folder. For this same reason, an output filename is not required, only the destination folder.
- The domain must be specified in decimal Latitude / Longitude coordinates (longitude as a negative) and fall within the constraints defined by the Alberta Subset and specified in Appendix A
- MMEU will automatically output all grid cells that are fully or partially contained by the user-specified domain.

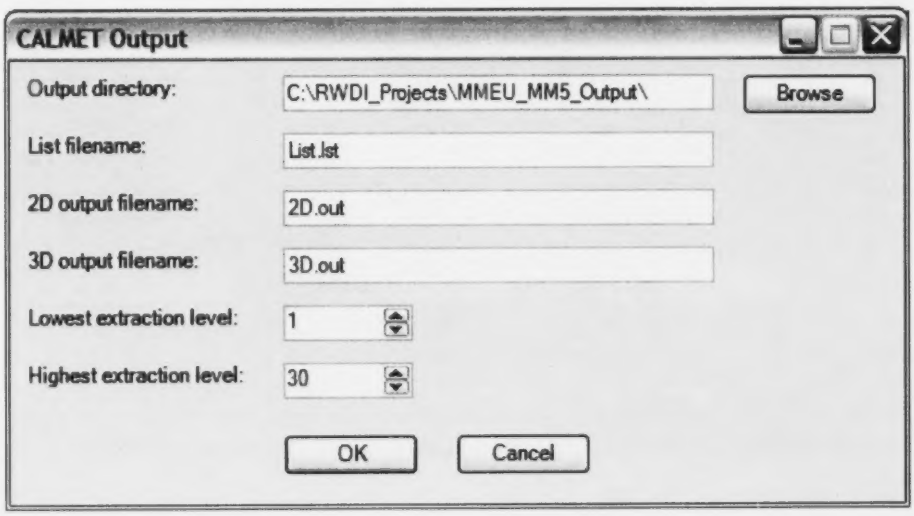
- The way in which some PCs are configured can limit the allowable size of any one file (e.g., there is a 2.0 Gb file size limitation for hard drives that are formatted as FAT32). The 'Check Inputs' button can be used to determine the estimated size of the output files prior to extraction. The onus is on the user to change the input parameters (namely period and / or domain extents) and re-check the resultant file size prior to performing an extraction.

- When performing an extraction, MMEU treats the original Environment Canada full domain as the 'Mother Domain' in reference to the I and J grid cell indexing of the resultant (i.e., child) output files.

- For more information on the MM5 file format, refer to http://www.mmm.ucar.edu/mm5

APPENDIX D. CALMET EXTRACTION OPTION


Multi-Model Extraction Utility
Location of Alberta MM5 input files:
C:\RWDI_Projects\Alberta_MM5_Files
Browse
Start Date: Tuesday , January 01, 2002
End Date: Sunday , December 31, 2006
Output file types
MM5
CALMET
ISC3
RTDM
AERMOD
NOTES:
For the specified domain and period, this option will execute the CALMM5.exe (ver 2.4) program and generate a run log file (.lst), a 2-D ASCII file, and a 3-D ASCII file for input to CALMET.
Files may be large, use the 'Check Inputs' button to view approximate output file sizes.
Latitude and Longitude (-ve)
Upper right coordinates: Lat: 57.50 Lon: -111.75
Lower left coordinates: Lat: 52.00 Lon: -116.25
Extraction Options
Closest 12km cell
Interpolated from 4 closest cells
Extract
Check Inputs
Exit
About
Aproximate CALMET files total size: 74.43 GB



CALMET Usage Notes

- For the sub-domain and period specified, this option executes the CALMM5.exe (version 2.4) executable and generates a run log file (.lst), a 2-D ASCII file (not used in CALMET), and a 3-D ASCII file for input to CALMET version 5.5313 Level 051216.

- The 3-D format file contains gridded precipitation data required to run with the wet deposition option in CALMET.

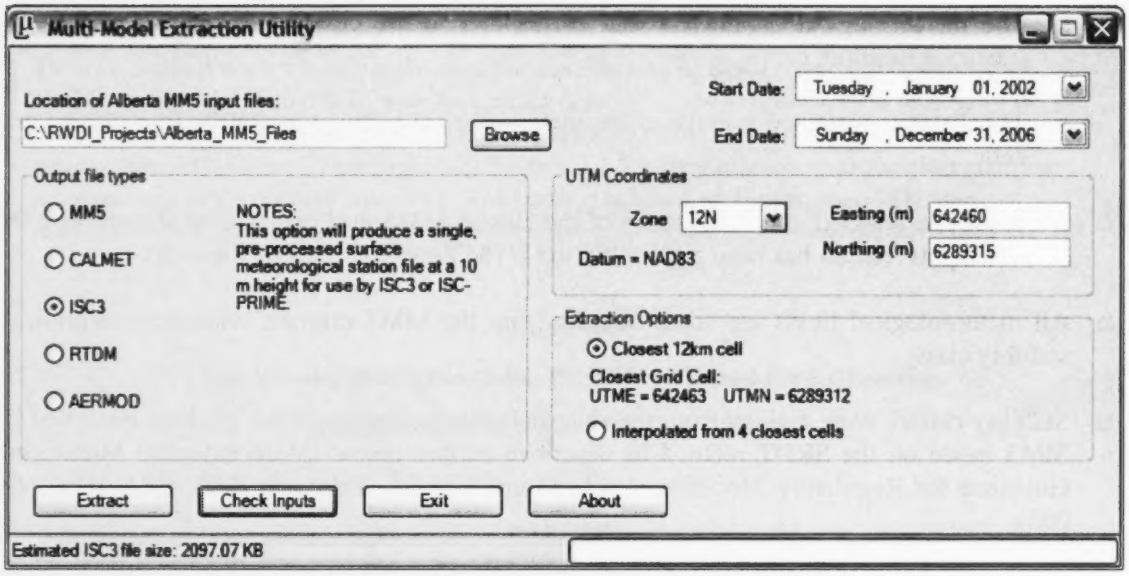
- The domain must be specified in decimal Latitude / Longitude coordinates (longitude as a negative) and fall within the constraints defined by the Alberta Subset and specified in Appendix A.

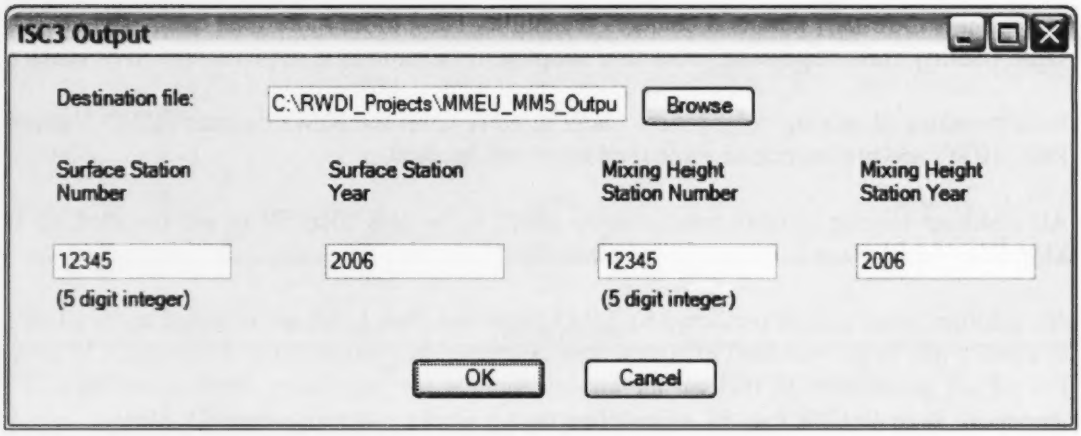
- MMEU will output all grid cells that are fully or partially contained by the user-specified domain.

- As part of the extraction process, the user must also provide the output file names and paths for all three output files to be generated, as well as the vertical levels to be extracted. The default spans all 30 vertical levels in the Alberta Subset MM5 files (i.e., Lowest = 1, Highest = 30).

- To facilitate this part of the extraction, MMEU calls and executes the freely downloadable CALMM5.exe (version 2.4) windows executable "as-is" and without warranty or condition of any kind as indicated in the End User License Agreement. The CALMM5.exe file must be located in the same windows folder as the MMEU.exe program for the CALMET option to function properly.

APPENDIX E. ISC3 EXTRACTION OPTION





ISC3 Usage Notes

- This option generates a single, pre-processed ASCII surface meteorological station file at a 10 m height for use with ISC3 or ISC-PRIME without wet or dry deposition parameters.
- The user must specify the desired extraction location in units of metres. The location can be specified in either UTM Zone 11 or 12, based on the NAD83 datum.

- Using a series of look-up tables internal to the software, MMEU will compare the user-defined location to the 12 km MM5 grid cells and allow the user to choose to extract an input file for either:
  - The meteorological parameters that correspond to the closest 12 km grid cell to the specified location; or,
  - The distance weighted average of the meteorological parameters for the four closest grid cells.
- If option 1 is selected, the coordinates of the closest MM5 grid cell will be shown once the 'Check Inputs' button has been pressed (in the UTM Zone specified by the user).
- All meteorological fields are taken directly from the MM5 outputs, with the exception of stability class.
- Stability classes were derived from the solar radiation and temperature gradient modelled by MM5 based on the SRDT method as described further below (Meteorological Monitoring Guidance for Regulatory Modeling Applications, USEPA, February 2000, EPA-454/R-99-005).
- As specified in the PCrammet manual, standard EPA practice in regulatory dispersion modeling is to restrict temporal changes in stability class to no more than one per hour. The same stability class smoothing procedure adopted in PCrammet is implemented in MMEU.
- Hourly values of mixing height were taken directly from the MM5 outputs (MM5 Variable PBL_HGT) and not estimated using the Holzworth method.
- All resultant mixing heights predicted by MM5 to be less than 50 m are rounded up by MMEU to equal 50 m as directed by Alberta Environment.
- All resultant wind speeds predicted by MM5 to be less than 1 m/s are rounded up by MMEU to equal 1 m/s as per standard EPA practices described in Section 9.3.4 of Appendix W of the US EPA's guidelines on the use air quality models for regulatory applications (US EPA Appendix W to 40 CFR Part 51 – Guideline on Air Quality Models, April 15, 1003).
- As part of the extraction process, the user must provide an output file name and path, as well as representative 5-digit integer values for both the 'Surface Station Number' and 'Mixing Height Station Number'. The user must also enter valid values for 'Surface Station Year' and 'Mixing Height Station Year'.

DESCRIPTION OF THE SRDT METHOD

6.4.2 Solar radiation/delta-T (SRDT) method

The solar radiation/delta-T (SRDT) method retains the basic structure and rationale of Turner's method while obviating the need for observations of cloud cover and ceiling. The method, outlined in Table 6-7, uses the surface layer wind speed (measured at or near 10 m) in combination with measurements of total solar radiation during the day and a low-level vertical temperature difference (ΔT) at night (see Section 3.1.2.1 for guidance on probe placement for measurement of the surface layer ΔT). The method is based on Bowen et al. **[37]** with modifications as necessary to retain as much as possible of the structure of Turner's method.

Table 6-7

Key to Solar Radiation Delta-T (SRDT) Method for Estimating Pasquill-Gifford (P-G) Stability Categories

DAYTIME

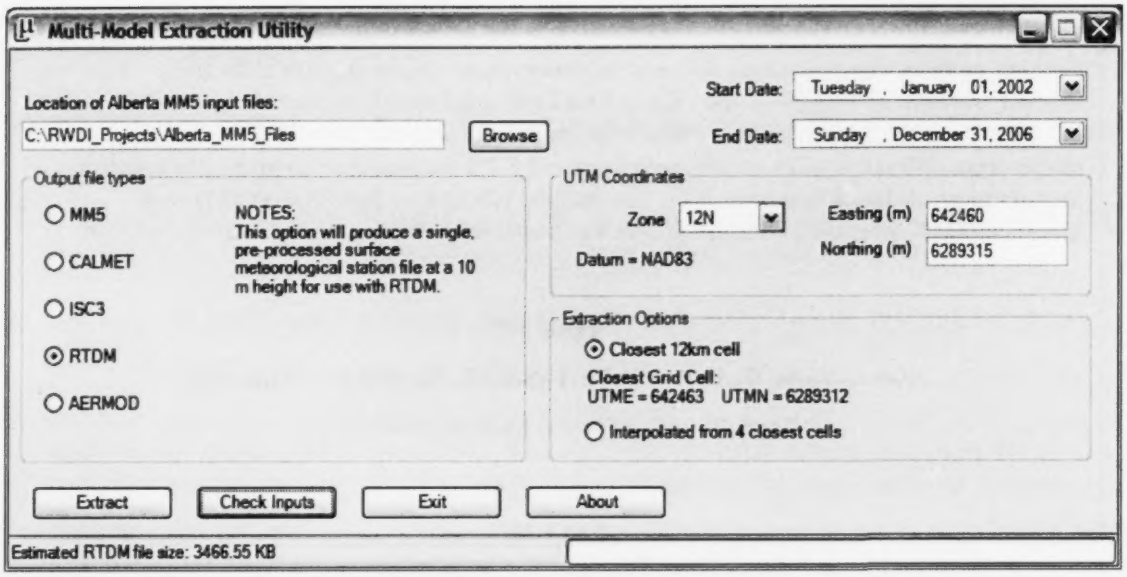
	Solar Radiation (W/m^2)			
Wind Speed (m/s)	≥ 925	925 - 675	675 - 175	< 175
< 2	A	A	B	D
2 - 3	A	B	C	D
3 - 5	B	B	C	D
5 - 6	C	C	D	D
≥ 6	C	D	D	D

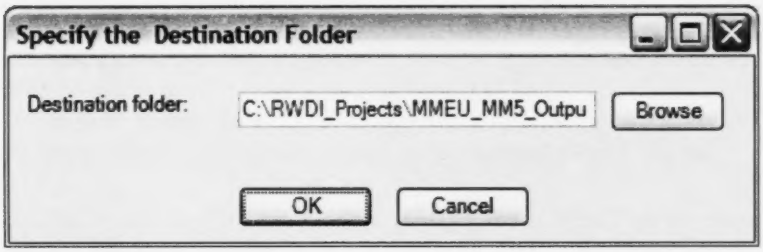
NIGHTTIME

	Vertical Temperature Gradient	
Wind Speed (m/s)	< 0	≥ 0
< 2.0	E	F
2.0 - 2.5	D	E
≥ 2.5	D	D

Source: *Meteorological Monitoring Guidance for Regulatory Modeling Applications, USEPA, February 2000, EPA-454/R-99-005.*

APPENDIX F. RTDM EXTRACTION OPTION





RTDM Usage Notes

- This option generates a single, pre-processed ASCII surface meteorological station file at a 10 m height for use with RTDM.
- The user must specify the desired extraction location in units of metres. The location can be specified in either UTM Zone 11 or 12, based on the NAD83 datum.
- Using a series of look-up tables internal to the software, MMEU will compare the user-defined location to the 12 km MM5 grid cells and allow the user to choose to extract an input file for either:
  - The meteorological parameters that correspond to the closest 12 km grid cell to the specified location; or,
  - The distance weighted average of the meteorological parameters for the four closest grid cells.

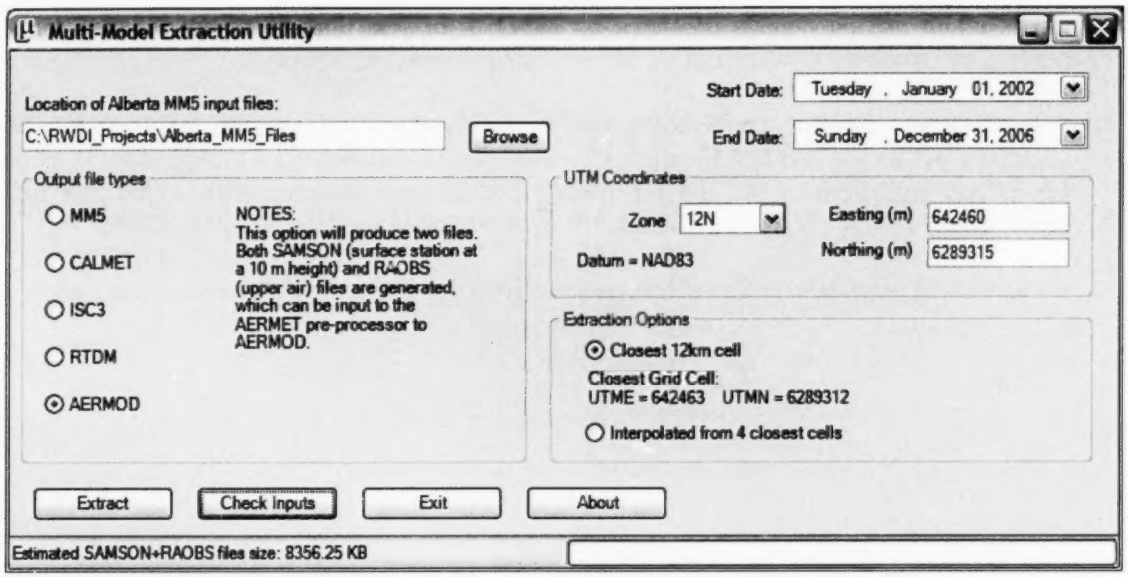
- If option 1 is selected, the coordinates of the closest MM5 grid cell will be shown once the 'Check Inputs' button has been pressed (in the UTM Zone specified by the user).

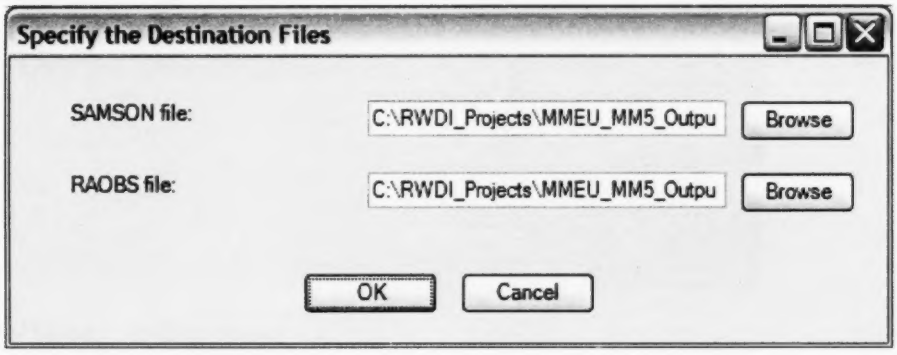
- All resultant mixing heights predicted by MM5 to be less than 50 m are rounded up by MMEU to equal 50 m as directed by Alberta Environment.

- All resultant wind speeds predicted by MM5 to be less than 1 m/s are rounded up by MMEU to equal 1 m/s as per standard EPA practices described in Section 9.3.4 of Appendix W of the US EPA's guidelines on the use air quality models for regulatory applications (US EPA Appendix W to 40 CFR Part 51 – Guideline on Air Quality Models, April 15, 1003).

- As part of the extraction process, the user must also provide an output file name and path.

APPENDIX G. AERMOD EXTRACTION OPTION





AERMOD Usage Notes

- This option generates two ASCII files: a SAMSON formatted surface station file at a 10- m height; and, a RAOBS (NCDC TD6201) upper air file, both of which can be used as input to the AERMET Stage 1 pre-processor to AERMOD.

- All meteorological fields required to run the pre-processor AERMET were derived from the MM5 outputs with the exception of cloud cover and ceiling height.

- An algorithm derived from code contained in the US EPA's Meteorology-Chemistry Interface Processor (MCIP) program was used to convert the condensed water in each vertical layer into a cloud fraction and extrapolate the ceiling height.

- The user must specify the desired extraction location in units of metres. The location can be specified in either UTM Zone 11 or 12, based on the NAD83 datum.

- Using a series of look-up tables internal to the software, MMEU will compare the user-defined location to the 12 km MM5 grid cells and allow the user to choose to extract an input file for either:

  - The meteorological parameters that correspond to the closest 12 km grid cell to the specified location; or,

  - The distance weighted average of the meteorological parameters for the four closest grid cells.

- If option 1 is selected, the coordinates of the closest MM5 grid cell will be shown once the 'Check Inputs' button has been pressed (in the UTM Zone specified by the user).

- All resultant wind speeds predicted by MM5 to be less than 1 m/s are rounded up by MMEU to equal 1 m/s as per standard EPA practices described in Section 9.3.4 of Appendix W of the US EPA's guidelines on the use air quality models for regulatory applications (US EPA Appendix W to 40 CFR Part 51 – Guideline on Air Quality Models, April 15, 1003).

- In order to run AERMET, the met pre-processor for AERMOD, a surface file in SAMSON format and an upper air file in NCDC TD6201 format need to be created. The details of those specific formats can be found in B and C, respectively.

- As part of the extraction process, the user must also provide output file names and paths for both the SAMSON and RAOBS output files.

DESCRIPTION OF THE SAMSON FORMAT

SURFACE DATA RECORD - SAMSON FORMAT

The first record in the file retrieved from the SAMSON CDs contains station data. The format of this record is:

Columns	Element	Definition
001	Indicator	- to indicate a header record
002-006	WBAN Number	Station number identifier
008-029	City	City where station is located
031-032	State	State where station is located
033-036	Time Zone	The number of hours by which the local standard time lags or leads Universal Time.
039-044	Latitude	Station latitude
039		N = north of equator
040-041		Degrees
043-044		Minutes
047-053	Longitude	Station longitude
047		W = west, E = east
048-050		Degrees
052-053		Minutes
056-059	Elevation	Elevation of the station in meters above sea level.

The FORTRAN format of this record is:

(1X,A5,1X,A22,1X,A2,1X,I3,2X,A1,I2,1X,I2,2X,A1,I3,1X,I2,2X,I4)

Each variable is represented by a position number. This position number always corresponds to that variable, no matter how many or how few variables are retrieved. The second record contains the list of variables (by a position number) that appear in the data file. There is no particular format; the variable number appears above the column of data it represents with at least one space (and usually many more) between the position numbers.

The third and subsequent records contain the weather elements retrieved from the SAMSON CDs. The data are free format, i.e., there is at least one space between each element in the record. The year, month, day, hour and observation indicator always appear on each record. These are followed by the variables retrieved by the user. If all the variables were retrieved, they would appear in the following order:

Position #	Description
	Year
	Month
	Day
	Hour (LST)
	Observation indicator
1	Extraterrestrial horizontal radiation
2	Extraterrestrial direct normal radiation
3	Global horizontal radiation
4	Direct normal radiation
5	Diffuse horizontal radiation
6	Total cloud cover
7	Opaque cloud cover
8	Dry bulb temperature
9	Dew point temperature
10	Relative humidity
11	Station pressure
12	Wind direction
13	Wind speed
14	Visibility
15	Ceiling height
16	Present weather
17	Precipitable water
18	Broadband aerosol optical depth
19	Snow depth
20	Days since last snowfall
21	Hourly precipitation amount and flag

The online help that accompanies the CDs contains a complete discussion of these variables, including the units, missing value indicators and any special considerations or comments.

Source: *PCRAMMET User's Guide, USEPA, June 1999, EPA-454/B-96-001.*

DESCRIPTION OF THE RAOBS (NCDC TD6201) FORMAT

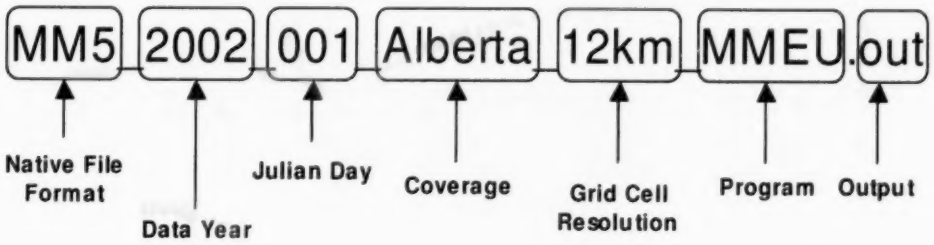
Parameter	Units	Format	File Location (Columns)
Station ID	-	XXXXXXXX	1 – 8
Latitude	Degrees N or S	XX	9 – 13
Longitude	Degrees E or W	XX	14 –19
Year	Year	XXXX	20 – 23
Month	Month	XX	24 – 25
Day	Day	XX	26 – 27
Hour	Hour	XX	28 – 29
Time Elapsed Since Accent*	Minutes and Tenths		34 – 37
Pressure*	KiloPascals and Hundredths	XXX	38 – 42
Height*	Geopotential Meters	XX	43 – 48
Dry Bulb Temperature*	Degrees F	XXX	49 – 52
Relative Humidity*	Tenths	X	53 – 55
Wind Direction*	Tens of Degrees From	XX	56 – 58
Wind Speed*	Knots	XX	59 – 61

* These parameters are repeated for up to 79 levels in the atmosphere.

Source: ***Preparation of Alberta Environment Regional AERMOD Screening Meteorology Data Sets, Alberta Environment, March 2002.***

APPENDIX H. ALBERTA 12 KM RESOLUTION MM5 FILES.

MM5 FILE NAMING CONVENTION:



Notes:

- Daily MM5 files are approximately 295 Mb in size (each), equating to a total of ~490 Gb for the entire 5 year dataset.
- RWDI provided the MM5 files and updated MMEU executable to Alberta Environment on an external USB hard drive.